**Digital leisure time activities, cognition, learning behaviour and information literacy: What are our children learning?**

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**Abstract**

Recent developments in digital technology have resulted in the unprecedented uptake of digital technology engagement as a leisure time pursuit across the age span. This has resulted in the speculation that such use of digital technology is responsible for changes in cognition and learning behavior. This study investigated 2 groups of school-aged learners (10—12 years) differentiated by their digital immersions level (n=48), defined by their scores on a leisure time digital immersion questionnaire. The study's general aim was to explore cognitive and educational differences between the 2 groups. Each group completed tests of attention and reasoning (verbal and non-verbal) and took part in two educational tasks where their learning behaviors were observed. Findings indicated that high digital leisure time immersion is predictive of attentional inconsistency and that high digital consumption behaviour is predictive of low literacy levels. Further, low digital immersion females and high immersion males perform poorly for an internet research task. However, all students were poor with regards digital information literacy skills. The results give rise to two recommendations for parents and educators of our millennial children.

**Keywords**: Cognition, reasoning, attention, learning behaviour, digital native, information literacy

Twenty first century life has become a digital experience with a large proportion of adults and children turning to technology as a leisure time pursuit (Lenhart et al, 2008). However, many schools lag behind the propensity for digital immersion. Prensky, (2001a; 2001b) argues that this predisposition towards digital activity has fostered two cultures; one of digital natives (born between 1980 and 1994), the other of digital immigrants (born before 1980), with significant consequences for our new generation of learners. Commentators claim that prolonged digital immersion can trigger major changes in behaviour and cause individuals to think and learn differently (Donaldson, 2006; Feiertag & Berge, 2008; Prensky, 2001a; Robinson, 2007). Brain plasticity (Nisbett, 2001) combined with increased exposure to digital devices is identified as the explanation for cognitive differences between digital natives and digital immigrants (Prensky, 2009; 2001a; 2001b; Oblinger, 2004). However, in reality we know little about how digital immersion actually affects cognition or educational experiences (Bennett, Maton & Kervin, 2008). Although Prensky views digital natives as a homogeneous group other researchers argue that digital engagement is heterogeneous. Helsper & Eynon (2010) suggest that viewing differences in technology use by year of birth, as Prensky does, is unhelpful and that researchers should view high and low technology users as defined by their use characteristics irrespective of age.

Other researchers distinguish between digital consumers and digital creators, suggesting that children from low income families are more likely to be consumers than creators. This distinction can be viewed as another facet of the digital divide because access to technology does not guarantee digital equality. It is important that individuals with access to technology also have the skills and opportunities to use it beneficially. Good computer and information literacy plays an important role in ensuring that users have the opportunities to use digital technology in an advantageous manner (Ebo, 1998; Besser, 2001). Besser (2001) contends that internet developers are producing more and more digital content for consumption rather than for digital creation. Therefore this combination of increased proliferation of media designed for consumption and the divide between those who have the skills to create and those who do not is producing a disturbing trend given that contemporary educational theory promotes active engagement rather than passive participation. From a different perspective Horrigan (2007, 2009) identified a typology of technology users defining 10 groups differentiated by their accessibility to technology (assets), their use of different media types (actions) and their perceptions of how the media affects their lives (attitudes). Only 2 of these groups appeared to be explicitly engaged in active creation, namely the‘Digital Collaborators’ and the‘Media Movers’.

Prensky (2001b) suggests that digital natives are more adept at tasks involving visual attention, visuo-spatial skills, inductive discovery and tasks where they need to respond quickly. However, these summations are based on the author's anecdotal experiences and require further research to substantiate his arguments. Subrahmanyam, Kraut, Greenfield & Gross (2000) reviewed the effect of computer use on academic performance and related skills and concluded that computer use was related to positive effects for a number of academic skills. However, most of the studies referred to by the researchers failed to differentiate between the effects of different types of computer use and referred to early computer adoption practices where more affluent families owned computers in a time when there was less of a proliferation of media content. Some researchers argue that digital immersion assists the development of visual selective attention, literacy, concentration, comprehension, problem solving, deductive reasoning and academic outcome. Others argue, to the contrary, that digital natives have decreased attention spans due to the large amounts of time spent moving from one activity to the next, commonly known as multi-tasking (McHale, 2005). Roberts, Foehr and Rideout (2005) made the association between the playing of computer games and reduced academic achievement grades, whereas exposure to print media was associated with improved grades. Schmidt and Vanderwater (2008) linked the use of e-media and computer games to improved visuo-spatial skills but to a reduction in attention skills. Ophir, Nass and Wagner (2009) used controlled experiments to demonstrate that individuals engaged in greater multi-tasking behaviour were more prone to interference effects and less able to sustain task concentration. They concluded that multi-taskers were poor at tasks requiring sustained concentration. Johnson (2009) reported higher levels of language and metacognition in children who used the internet at home for learning and communication. However, they found no differences in academic measures for those children who engaged in online game playing and internet browsing. Jackson, et al (2006) reported higher reading scores in more frequent users of the internet for children from low income families. It is clear that leisure time digital engagement has some potential as a learning medium (Sefton-Green, 2004) but the evidence is mixed as to whether in its current state digital engagement enhances cognitive and educational outcomes or whether it is detrimental. There is a clear need for more research in this area to clarify and disentangle some of these issues.

Others have considered the effects of digital immersion on children's information literacy skills. The Digital European Literacy Program (Rosado & Belisle, 2006) divides information literacy into three key components:

1. Working with Information
2. Creating and sharing information and
3. Using ICT responsibly.

The document centres on the raising of standards of digital literacy through key education stakeholders and emphasizes the importance of schools in such an endeavour. The internet has been offered as playing a major role in supporting information retrieval for many school children when completing school work at home (Livingstone & Bober, 2004).
Livingstone & Bober (2004) articulate that "Young people encounter difficulties with searching the web, with the critical evaluation of website contents and with a range of other online skills, and these in turn appear due to the patchy educational support they have received in Internet literacy teaching" (p413). However they also emphasize in the UKCGO study that children prefer to learn internet skills informally using a more trial and error method than through formal teaching and learning. In the same survey 69% of children who were non users of the internet and 36% of internet users indicated that they had not received any formal instruction on how to use the internet. Further, 87% of children and young people considered themselves as competent in finding information on the internet. Such findings are supported by Coombes (2008) who articulates that generation Y are confident users of technology but this fact does not mean that they are also competent users. The question remains as to whether children more immersed in digital behavior show greater digital literacy skills than those less engaged.
It is important that educators understand the effect of leisure time digital immersion on their learners (Sefton-Green, 2004), especially if educational establishments, such as schools, are to keep pace with the changing digital culture. If contemporary digital culture is having an effect upon cognitive functioning, learned behaviours and learning behaviours it is imperative that educational establishments adapt to the educational needs of the learners.

Few studies have empirically investigated the connection between cognitive and educational outcomes and leisure time digital immersion particularly in pre teen populations. An understanding of the links between leisure time pursuits and cognition are important for educators as such links may be utilized to leverage technology and enhance learning (Sefton-Green, 2004).

This study explores 2 groups of school-aged learners (10—12 years) differentiated by their digital immersions level. One group reported being high leisure time digital users, across a range of digital activities, the other group reported low digital behavior patterns. The study's general aim was to explore cognitive and educational differences between the 2 groups. To this end, the study looks at quantitative differences between the two immersion groups in terms of their digital behavior patterns, ascertains whether reasoning and attention ability differ between the two groups and explores whether there are any differences between the two groups in their approach to two educational tasks. The first educational task asks students to

research a particular topic using whatever means they wish (books or digital) and looks for choice and attainment differences between the two groups, the second task asks students to use the internet to research a task and explores attainment differences and observes their online internet search behaviours. Specifically this project investigated:

1. Whether high and low digitally immersed children differ in terms of their attention and concentration.
2. Whether high and low digitally immersed children differ in terms of their reasoning ability.
3. Whether types of digital engagement were associated with differences in cognition scores.
4. Whether high and low digitally immersed children differ in terms of their attainment on a research task.
5. Whether high and low digitally immersed children differ in terms of their attainment on an internet fact finding task.
6. Whether high and low digitally immersed children differ in terms of the way they approach and use resources in a research task.
7. Whether high and low digitally immersed children differ in terms of the way they approach and use the internet in an internet fact finding task.

## Methodology

### Design

A sample of 224 children from a range of schools across the Canterbury region completed an digital immersion questionnaire that detailed their digital activities in their leisure time. Forty eight of these children were then selected as the highest and lowest scoring in their respective schools according to an immersion score derived from their responses to the digital immersion questionnaire. These final 48 children comprised the high (24) and low (24) digital immersion groups for this study. Each group was then given tests of reasoning and attention and was observed completing two educational tasks (a research task and an internet task). Student behavior during the tasks was video-taped and all computer activity was recorded using screen capture technology. Comparisons were then made between the high and low digital immersion groups and their levels of reasoning and attention/concentration. In addition, comparisons between the groups' performance and behaviour on the research and internet tasks were made using both quantitative and qualitative analyses.

## Participants

Two Hundred and Twenty Four participants (139 males, 85 females) aged 10-12yrs from the New Zealand Canterbury region completed a digital immersion questionnaire. Participants were recruited from 10 primary schools with decile ratings ranging from 2–10 (New Zealand schools are graded on a scale of 1-10 called decile rating that depicts the extent to which a school draws its students from low socio-economic communities). On questionnaire completion a sub sample of 48 participants (23 male, 25 female) were selected to take part in the second part of the study. These students were selected by choosing the highest and lowest scoring students from each school and balancing for overall gender (24 high, 24 low) on the digital immersion questionnaire (See table I). This initial immersion score was calculated agnostic of the type of digital engagement that was being undertaken by these student and was calculated by taking the relative time these students indicated that they spent on digital activities overall, calculated by summing across all 28 items. This approach assumes that immersion is about the amount of time participants spend engaged in digital activity and does not take account of the qualitative differences between different types of digital activity.

TABLE I ABOUT HERE

## Materials

### *Digital Immersion Questionnaire*

A comprehensive questionnaire was designed to survey the type and extent of digital behaviour that students were engaged in during their leisure time. The questionnaire included a question asking participants to indicate how often they perform the following 28 digital activities. These digital behaviours were subsequently broken down into creation, consumption and communication groupings (see Table II).

1. Use a computer for writing blogs
2. Create webcasts or podcasts
3. Listen to or download webcasts or podcasts
4. Use the computer for creating web pages
5. Download pictures from the internet
6. Use the computer for chatting e.g. MSN
7. Use a computer and microphone for talking

8. Download programs from the web
9. Participate in web discussion forums
10. Use the computer to surf the web
11. Play computer games on the internet
12. Use the computer for email
13. Play computer games on a PC or Mac
14. Listen to music on the computer
15. Listen to music on a MP3 player e.g. iPod
16. Use a mobile phone to text
17. Use a mobile phone to talk
18. Listen to music on my mobile phone
19. Use a mobile phone to surf the web
20. Play computer games on a mobile phone
21. Use the computer for writing
22. Use the computer for drawing
23. Use a digital camera
24. Use a digital video camera
25. Use the computer for editing video movies
26. Install computer programs from DVD/CD
27. Use the computer for composing music
28. Play computer games on a console

Students' responded; never, sometimes, often or all the time and responses were coded as never=0, sometimes=1, often=2, all the time=3; thus allowing a minimum immersion score of 0 and a maximum of 84.

*Reasoning Tests*

A 55 item standardized reasoning skills test booklet developed by the University of Canterbury Centre for Evaluation and Monitoring (CEM) for use with primary aged children was used to assess reasoning skills. This test is commonly used by schools in the Canterbury Region of New Zealand to assess children's reasoning skills and has sound psychometric properties. The test included simple logic, deductive reasoning and inductive reasoning skills. Twenty two items assessed literacy, 22 items assessed numeracy and 11 items assessed abstract reasoning (pictorial). Reasoning skills tests are a good ability measure and can be good predictors of academic success (Lawson, 1982).

*Tests of Attention*

The d2 test of attention (Brickenkamp & Zillmer, 1998) is a timed test of selective attention and mental concentration designed for use with 9-90 year old participants and is deemed valid and reliable. Items are composed of the letters "d" and "p" with one, two, three or four dashes placed either individually or in pairs above and below the letter. Participants are given 20 seconds to scan each line and indicate all "d's" with two dashes. The test consists of 14 lines of 47 characters each and a total of 658 items. Measures of performance include an index of concentration performance (CP), total number of items correct minus errors (TN - E), and fluctuation rate across trials (FR). Concentration Performance (CP) is the number of correct items minus errors and is a good measure of speed and accuracy of performance. TN-E is a measure of Quantity of work completed after correction for errors and a good measure of Attention/inhibitory control. TN-E is described by the manual as "the total number of items scanned minus error scores…… It is a measure of attentional and inhibitory control and the relationship of speed and accuracy of performance." (Brickenkamp & Zillmer, 1998; p11). Fluctuation rate (FR) shows the discrepancy between the line with the maximum number of items processed and the line with the minimum number of items processed. Extremely high raw scores can suggest an inconsistency in work speed perhaps related to poor motivation.

*Research Task*

Students were asked to research a particular era in English history and present a report on their findings. They were given 45mins to complete the task and allowed to use any resources that were available in the work room. Resources available included a computer linked to the internet, a printer and numerous books providing information on the topic. The instructions given to the participants are shown in Appendix 1. Participants' reports were blind marked by two independent markers. Markers were instructed to allocate one mark for each correct fact about England in1666. An inter-rater reliability test indicated a reliability coefficient of .96 which is sufficient to indicate that reliability between markers was good.

*Internet Task*

Students were asked to answer a number of questions about a particular topic using only internet resources. They were given 15mins to complete this task and asked to record their responses. This was considerably less time than given for the research task because the task was better defined and participants were given explicit instructions to use the internet. The instructions that were given to the participants are shown in Appendix 2. Participant responses were blind marked by two independent markers. Markers were given specific facts about the invention of the battery that could be used in a student's answer and the number of marks allocated to each fact. An inter-rater reliability test indicated a reliability coefficient of .97 which is sufficient to indicate that reliability between markers was good.

*Observations*

All student task sessions were video recorded using a Macbook and a camera and were recorded directly to hard disk. Any computer activity undertaken by students was captured using SnagIt8™ a commercially produced screen capture program.

Procedure

Ten Canterbury primary schools agreed to take part in the project and year 6 teachers within these schools were approached and informed of the procedure and purpose of the research. All year 6 children in each school were given information sheets describing the research and parent/guardians and students were asked to complete permission slips. Students who returned permission slips were included in phase 1 of the project and asked to complete the digital immersion questionnaire. Instructions on questionnaire completion were communicated by the researcher to all participants. Questionnaires were then completed in class with the help of the teacher and the researcher (if required). No time limits were placed on participants for completing the questionnaires and the researcher and teacher checked all questionnaires on collection. Questionnaires were then collated and entered into a spreadsheet for initial analysis. Sample 2 was selected according to total immersion score across all 28 digital engagement items and balanced by school attended and gender.

In phase 2 of the project participants (N=48) were asked to complete the attention test and the reasoning test. Participants were tested in groups of 4-6 in a separate quiet room within the school and different tests were completed on different days to avoid fatigue effects. Strict test conditions were adhered to and instructions were clearly relayed to students. Participants in each group started the tests together and finished together and then asked to return to their classrooms.

In phase 3 of the project participants (N=48) were asked to attend the work room individually and allowed 45 minutes to complete the research task using the resources provided. At the end of 45 minutes they were stopped and their reports were collected. The internet task was generally completed the day following the research task. A similar procedure was used for the completion of this task with participants attending the work room individually where they were allowed 15 minutes to complete the task and then thanked and asked to return to class.

Analysis

Percentages were calculated for the amount of time participants spent on each of the 28 digital behaviours differentiated by immersion level (high, low) and type of digital behavior, based on Bosah's (1998) classifications but with the addition of a communication category,

(communication, creation, consumption) to show a description of the behaviours of each immersion group (table 2). MANOVA was conducted on the 3 reasoning scores and 3 attention scores as dependant variables with immersion level (high, low) and gender as independent variables. In addition, regression analyses were conducted with the 6 cognition scores as dependant variables and raw creation, consumption, communication scores as independent variables to ascertain whether the three types of digital activity predicted cognition scores. Two univariate analyses of variance were conducted using the research task and internet task attainment scores as dependant variables with immersion level (high, low) and gender as independent variables and reasoning score as a covariate to control for ability. The research task was analysed by observing the videos of the participants undertaking the task and the following information was collated: percentage of time spent using books, initial medium chosen (book or internet), form of final report (word processed or handwritten), and whether the participant printed any supporting documents. Finally the internet computer logs of 3 high immersion and 3 low immersion individuals were examined qualitatively to establish their internet research skills.

**Results**

*Digital Behaviour Levels*

Table II shows that high and low immersion groups show distinct patterns of digital engagement. Low immersion individuals showed lower levels of engagement for all digital activities and hardly engaged at all in a number of higher level digital activities such as Internet Messaging (IM) with the computer, web discussions, composing music and web pages, creating podcasts, downloading and installing programs, writing blogs, creating movies and listening to music on mp3 players. However, it appears that for both groups the proportions of students engaging in creation, communication and consumption activities were similar. Some activities between the two groups were clearly more similar in terms of engagement than others. Texting on a phone and writing and drawing on the computer were activities more likely to be undertaken more regularly by both groups. Surfing the web however shows distinct differences between the two groups with 33% of low immersion students surfing the web and 87.5% of high immersion students surfing the web. The statistics in table 2 show many differences in digital behavior between the two groups. Table III differentiates between genders and immersion levels for consumption, creation and communication and shows that boys tend to engage in more consumption and creation activities than girls, whereas both genders are equal in terms of the communication behaviors that they engage in.

TABLE II ABOUT HERE

TABLE III ABOUT HERE

*Reasoning and Attention*

MANOVA revealed a significant difference between high and low immersion groups for literacy reasoning ($F=8.56$, $df=44,1$, $p=0.006$) showing that overall low immersion individuals had higher literacy reasoning scores (low $M=7.6$, $sd=3.7$; high $M=6.2$, $sd=1.8$). In addition, a significant difference was found between high and low immersion groups for fluctuation rate ($F=5.65$, $df=44,1$, $p=0.022$), a measure that indicates the consistency and stability of performance in the attention test. High immersion individuals showed greater inconsistency (low $M=15.8$, $sd=9.5$; high $M=20.1$, $sd=7.3$). Six regression analyses were conducted with each of the cognitive factors as dependant measures and consumption, communication and creation as the independent variables. This revealed only one significant model for literacy being predicted by consumption behavior and showing that as consumption behaviour increases literacy reasoning decreases (Table IV).

TABLE IV ABOUT HERE

*Task Attainment*

Results for the two educational tasks tended towards equivalence apart from a significant cross over interaction between gender and immersion level for the internet task ($F=6.84$, $df=1,39$, $p=0.013$). Low immersion males and high immersion females performed best on this task (see Figure 1). Low immersion females performed particularly poorly.

FIGURE 1 ABOUT HERE

*Research Task Behaviour*

Percentage of time spent on books was calculated during the research task (see figure 2) and although not statistically significant (marginal) it showed that low immersion individuals tended to spend more time using books compared to high immersion individuals (low $M=49.9\%$, $sd=35.8$; high $M=32.3\%$, $sd=28.3$). In addition, low immersion individuals were more likely to begin the task by using books rather than by using digital resources (see Figure 3).

FIGURE 2 ABOUT HERE

FIGURE 3 ABOUT HERE

*Internet Behaviour*

Both the research task online behavior and internet task online behaviour were examined and the following are some brief summaries (narratives) typical of participant behaviour for high and low immersion students, names are fictitious.

**Andrea (High Immersion)**: Easily accessed internet explorer and Google Search, managing to navigate between the two with relative ease. She printed out work relatively easily but had some minor problems printing discrete sections of the work; she opted to print it all. Her search strategies were poor. For example she used the following: "London", "what important people in London", "what important things happening in London", such terms generated mainly irrelevant search results (given that she needed to find information about London in 1666). She also had problems choosing relevant search results even when some relevant results were generated. Many of the websites that she entered were referring to modern London rather than historical London (not surprising given the search terms used). She spent a lot of time looking at a number of irrelevant websites that gave no useful information.

**Amelia (High Immersion):** Although she managed to open a browser she struggled to find an appropriate search engine. When she did she was unsure how to use it. For instance she initially typed search terms into the MSN Xtra 'search for products' search box. She then typed some terms into the correct MSN search box but failed to activate the search. For the internet task she managed to access Google Search engine and then used the search term 'electricity', this yielded many modern (not historical) results. Consequently, she clicked on the 'electricity commission' website and began to explore this. Most of her time was spent looking at irrelevant websites. Finally she accessed Wikipedia and printed 7 pages from the 'electricity' entry (irrelevant information).

**Andrew (High Immersion):** He had no problems accessing a browser and Google search. However, once in Google search he had trouble searching for relevant information. He spent some time entering search terms into the search engine but then clicked on 'book results'. This generated a number of results related to books. He then began to enter search terms into the engine and searched within the images section of the engine. His initial search terms were reasonable, for example he used: "what transport do they use in 1666 in London?" but due to him using the wrong part of the search engine, results were poor. His search terms then degenerated to more general terms such as: "cars in London", "cool cars". He opened word and copied and pasted pictures of modern transport. For the internet task he used appropriate search terms in Google but his choice of search results was poor thus providing him with information that was not very relevant, although some relevant search results were generated.

**Ben (Low Immersion):** Needed help to access a browser. Initially he tried to type "electricity" into the address bar of Internet Explorer (IE). He then typed: "who invented the battery" into Internet Explorer's web address bar. He then tried "electricity' again in address bar. Finally, Internet Explorer did a search for electricity and generated some search results. He quickly scanned the results and found nothing useful. He went back to the yahoo page in the browser and typed some new terms, this time into the correct search box and found what he wanted.

**Beverley (Low Immersion)**: Initially needed help to get onto a browser. She then entered "1666 London" into the search box and scanned the results. Although some good results were generated she didn't choose any of them. She then returned to the Internet Explorer home page (Xtra MSN) and changed her search terms but this time spelled London incorrectly. This generated a number of results that were written in German. She selected one of the German websites to find that she couldn't read the information. She spent a lot of time entering incorrectly spelled search terms into the search box and scanning the results with little success. Her behaviour during the internet task was very similar. She entered incorrectly spelled words but didn't utilize the 'Did you mean…' option that is generated in a search engine. Consequently, she spent the whole 15 minutes going backwards and forwards between the search engine and the results to no avail.

**Briony (Low Immersion):** Opened Firefox and used the search box in Xtra MSN. Started by entering the search terms "Who are the important people in England 1666". From the results she chose a result that gave no useful information. She then went back to the results list and chose a more appropriate result that told her about the Great Fire of London, having spent some time looking at this she then returned to the search box and changed the search terms to "transport england1666" which failed to return any results due to the lack of spacing between England and 1666. She then re entered the search terms "1666 London" which generated a number of results of which she chose a site about the Great Fire again. She spent the rest of the time entering search terms (ineffective ones) to try to get information about transport and clothing in London during that period but failed to find any useful websites.

**Discussion**

Examination of the percentage engagement for different digital activities for high and low engagement groups indicated different patterns for each group. Both groups were frequently engaged in low level uses of technology such as texting, emailing, writing and drawing on the

computer and playing games. However, the high group was much more likely to be engaged in more sophisticated uses of technology (e.g. blogs, composing music, creating web pages). This is reflected in the higher percentage shown for the 'creation' category for high users compared to that of low users. It is also probably worth noting that low users, compared with high users, were slightly more inclined to use technology for communication than for consumption or creation. This observation supports other researchers who have found that digital users tend to show different characteristics of use (Horrigan, 2007, 2009), with clear differences emerging between high and low users of technology in this study. In addition, males tend to show some preference towards consumption and creation compared to females.

The first two research questions asked whether high and low digitally immersed children differed in terms of their reasoning, attention and concentration test scores. Results clearly indicate that high immersion children tend to have lower literacy reasoning levels. However, no cause and effect relationship between immersion levels and literacy aptitude can be established in the current study because of the correlational nature of the design. Further examination of the data exploring whether the type of engagement predicts literacy levels, using regression analysis suggests that those individuals with higher 'digital consumption' levels tend to demonstrate lower literacy levels. Although actual cause and effect relationships cannot be established in this study it does indicate a clear relationship between consumption behavior and low literacy levels. Such a relationship could be due to individuals with low literacy levels being attracted to the more mindless consumption elements of technology or it could suggest a more causal relationship with the consumption of digital media being detrimental to academic literacy levels. Such results support other researchers in the area who claim that digital preoccupation reduces academic attainment (Roberts, Foehr & Rideout, 2005). Such results might indicate that as parents, teachers or educators we should be encouraging children to use digital technology more actively and creatively, perhaps through more creation and communication, and therefore attempt to minimize mindless digital consumption.

Similarly, results from the attention test indicated that high digital immersion individuals showed higher fluctuation rates (FR) indicating that these individuals were more prone to inconsistency within the actual attention test. In reality this means that high immersion individuals tended to attain high scores on some parts of the attention test and attain low scores on others, rather than perform consistently. This could be interpreted as a lack of motivation for the test or inconsistency caused by external distracters. High immersion individuals may struggle to maintain concentration over longer periods of time, as was required for this test. Such results support Schmidt and Vanderwater (2008) and Ophir, Nass

and Wagner (2009) who linked the high use of technology to reductions in attention. Further exploration through regression analysis did not indicate that any specific types of use (consumption, creation, communication) were associated with reductions in attention. However, Ophir, Nass and Wagner (2009) linked reduced attention to multi-tasking behavior which was not specifically explored in this study.

The third and fourth research questions asked whether high and low digitally immersed children differ in terms of their attainment on a research task and internet task. Results indicated that there were no differences for attainment on the research task when given a choice of materials to use that included traditional materials such as books and the internet. However, a significant interaction effect emerged for the internet task where participants were required to use only internet resources to research a particular topic. Results indicated that low immersion females performed worst and high immersion females performed best on this task with the reverse effect for males. Furthermore, high and low immersion females showed greater differences in attainment compared with high and low immersion males. This effect indicates that females who are more familiar with using technology excel compared with females who rarely use digital resources for a task that relies on such resources. This is no surprise and is what would be expected of a task suited to individuals with digital inclinations, compared to those without. However, the trend for males is much more curious as it indicates the reverse effect. Given that the analysis controlled for reasoning ability it is unlikely that the pattern for males is due to low immersion males being of higher ability. One explanation for such a result is that low immersion and high immersion males undertake different types of digital engagement, with high immersion males concentrating on leisure time activities that are not useful for an internet search task such as this. However, low immersion males (although less immersed) may be engaging in more relevant digital activities that support the skills required for such a task. This may be somewhat reflected in the amount of in consumption behaviour demonstrated by high immersion males (85.5%), which was the highest proportion of behavior demonstrated by any of the groups. It should also be noted that the participants were given longer to complete the research task than the internet task, therefore the time element may have been a factor that contributed to the differences between the groups for this task. However, given the nature of the internet task compared to the research task and the explicit instructions given this is unlikely as the research task was a task requiring more time. It is more likely to be related to the lack of choice and the nature of the task.

Research question 5 asked whether high and low immersion children differ in terms of the way that they approach and use resources in a research task. Results indicated that low

immersion individuals tended to spend more time using books than high immersion individuals and that they were also more likely to begin the research task using books rather than digital resources, when given the choice. It is likely that children who are more immersed in technology at home may be more inclined to utilize technology in other contexts such as this, when they are given a choice, and this was evident here. It should be emphasized that this difference between the time using books and time using the internet was not statistically significant. However, this may be explained by the following section describing these children's behaviour whilst on the internet.

Research question 6 asked whether high and low immersion children differ in terms of the way they approach and use the internet in an internet fact finding task. It was expected that the high immersion group who spend more time around digital technology would have a better grasp of using technology for this type of task. Observations indicated that although high immersion individuals were marginally more skilled at accessing and navigating the digital environment they were, in fact, no better at negotiating search engines to find appropriate information. Both high immersion and low immersion individuals were consistently poor at choosing the appropriate search terms and scanning and choosing the most appropriate search results, with high and low immersion children struggling to find anything useful in the time allocated for the task that they were given. Therefore in relation to the previous research question although high immersion students were more eager to use the internet (shown by the time spent on books and initial choice of medium) for the research task, once they were using the technology they soon found that they did not have the necessarily skills to complete the task, often getting frustrated, and reverting to books as a last resort. Therefore it is likely that lack of skills by high immersion individuals with internet resources mediated the time spent on books.

Although many students are choosing technology as their preferred source of information, they appear to be lacking in skills appropriate to the task. In other words, this study supports previous studies that show school aged students are lacking key digital information literacy skills required to use internet resources to secure reliable and valid information via the internet (Coombes, 2008; Livingstone & Bober, 2004). Such skills are unlikely to evolve naturally and often need to be taught. However, it seems that primary schools rarely teach such skills, mainly opting for the more traditional skills of research using books. It is extremely important that schools address such skills much more pro actively, especially given that many of our children are now spending many hours on computers in their leisure time and that engagement with digital devices is developing early in a child's life. Digital skills such as these are becoming an important life skill given that computers are so ubiquitous in society. Two recommendations are forthcoming from this study:

1. Parents and educators should encourage children to use technology in an active way through creation and communication and moderate the amount of consumption behavior to a minimum.
2. Educators should put more time into educating children about digital information literacy as is recommended by the Digital European Literacy Program (Rosado & Belisle, 2006).

*Limitations*

The study comes with a number of limitations including that of small numbers for the quantitative part of the project. However, for practicality reasons these were restricted by the need to work with individual children for the purposes of a more in-depth analysis. In addition, the study is restricted to a New Zealand population and some of the conclusions drawn about how schools might educate their students with regards digital information literacy should be treated carefully as it is recognized that these factors will change from country to country. However, New Zealand is very similar to the U.S and European in many ways, being one of the developed countries of the world.

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*Table I: Immersion score range (min=0, max =84) and N differentiated by school attended*

| | ***Low Immersion Range and N*** | ***High Immersion Range and N*** |
|---|---|---|
| **School A** | 9-15 (N=3) | 54-61 (N=2) |
| **School B** | 1-10 (N=3) | 49-68 (N=3) |
| **School C** | 7-12 (N=3) | 38-51 (N=3) |
| **School D** | 16-20 (N=2) | 38-52 (N=2) |
| **School E** | 7-10 (N=2) | 54-60 (N=2) |
| **School F** | 9-10 (N=2) | 36-48 (N=2) |
| **School G** | 23-23 (N=2) | 26-59 (N=3) |
| **School H** | 0-7 (N=2) | 31-42 (N=2) |
| **School I** | 4-18 (N=3) | 26-48 (N=3) |
| **School J** | 11-12 (N=2) | 48-51 (N=2) |
| **Total** | 0-23 (N=24) | 26-68 (N=24) |

Table II. Percentage engagement for each digital behavior factor differentiated by immersion group and type of engagement

| | Low Immersion Group | | | | High Immersion Group | | | |
|---|---|---|---|---|---|---|---|---|
| | **Never** | **Sometimes** | **Often** | **All the time** | **Never** | **Sometimes** | **Often** | **All the time** |
| **Communication** | | | | | | | | |
| use the computer for chatting e.g. MSN | 95.8 | 0 | 0 | 4.2 | 20.8 | 12.5 | 20.8 | 45.8 |
| use a computer and microphone for talking | 95.8 | 0 | 0 | 4.2 | 33.3 | 25.0 | 12.5 | 29.2 |
| participate in web discussion forums | 100.0 | 0 | 0 | 0 | 50.0 | 29.2 | 12.5 | 8.3 |
| use the computer for email | 54.2 | 33.3 | 12.5 | 0 | 4.2 | 20.8 | 20.8 | 54.2 |
| use a mobile phone to text | 29.2 | 58.3 | 4.2 | 8.3 | 8.3 | 12.5 | 25.0 | 54.2 |
| use a mobile phone to talk | 62.5 | 25.0 | 8.3 | 4.2 | 8.3 | 29.2 | 37.5 | 25.0 |
| **Communication means** | **72.9** | **19.4** | **4.2** | **3.5** | **20.8** | **25.0** | **21.5** | **36.1** |
| | | | | | | | | |
| **Creation** | | | | | | | | |
| use the computer for writing | 25.0 | 50.0 | 16.7 | 8.3 | 4.4 | 8.3 | 29.2 | 58.3 |
| use the computer for drawing | 29.2 | 50.0 | 8.3 | 12.5 | 4.2 | 8.3 | 33.3 | 54.2 |
| use a digital camera | 41.7 | 50.0 | 8.3 | 0 | 16.7 | 29.2 | 20.8 | 33.3 |
| use a digital video camera | 69.6 | 30.4 | 0 | 0 | 12.5 | 37.5 | 20.8 | 29.2 |
| use the computer for editing video movies | 87.5 | 8.3 | 4.2 | 0 | 43.5 | 34.8 | 17.4 | 4.3 |
| install computer programs from DVD/CD | 83.3 | 16.7 | 0 | 0 | 25.0 | 25.0 | 29.2 | 20.8 |
| use the computer for composing music | 100.0 | 0 | 0 | 0 | 8.3 | 45.8 | 12.5 | 33.3 |
| download programs from the web | 83.3 | 16.7 | 0 | 0 | 25.0 | 8.3 | 33.3 | 33.3 |
| create webcasts or podcasts | 100.0 | 0 | 0 | 0 | 62.5 | 20.8 | 4.2 | 12.5 |
| use the computer for creating web pages | 87.5 | 12.5 | 0 | 0 | 47.8 | 21.7 | 13.0 | 17.4 |
| use a computer for writing blogs | 91.7 | 8.3 | 0 | 0 | 66.7 | 12.5 | 4.2 | 16.7 |
| **Creation Means** | **72.6** | **22.1** | **3.4** | **1.9** | **28.8** | **22.9** | **19.8** | **28.5** |
| | | | | | | | | |
| **Consumption** | | | | | | | | |
| play computer games on a console | 70.8 | 29.2 | 0 | 0 | 8.3 | 8.3 | 41.7 | 41.7 |
| play computer games on a mobile phone | 66.7 | 20.8 | 8.3 | 4.2 | 12.5 | 25.0 | 29.2 | 33.3 |
| listen to music on my mobile phone | 75.0 | 16.7 | 0 | 8.3 | 4.2 | 25.0 | 29.2 | 41.7 |
| use a mobile phone to surf the web | 87.5 | 8.3 | 4.2 | 0 | 33.3 | 20.8 | 33.3 | 12.5 |
| play computer games on a PC or Mac | 45.8 | 33.3 | 12.5 | 8.3 | 8.3 | 16.7 | 25.0 | 50.0 |
| listen to music on the computer | 66.7 | 25.0 | 4.2 | 4.2 | 8.3 | 16.7 | 41.7 | 33.3 |
| listen to music on a MP3 player e.g. iPod | 88.3 | 12.5 | 4.2 | 0 | 25.0 | 25.0 | 12.5 | 37.5 |
| use the computer to surf the web | 66.7 | 29.2 | 4.2 | 0 | 12.5 | 12.5 | 29.2 | 45.8 |
| play computer games on the internet | 45.8 | 29.2 | 16.7 | 8.3 | 0 | 20.8 | 33.3 | 45.8 |
| download pictures from the internet | 62.5 | 29.2 | 8.3 | 0 | 12.5 | 12.5 | 37.5 | 37.5 |
| listen to or download webcasts or podcasts | 95.8 | 4.2 | 0 | 0 | 45.8 | 29.2 | 12.5 | 12.5 |
| **Consumption Means** | **70.1** | **21.6** | **5.7** | **3.0** | **15.5** | **19.3** | **29.6** | **35.6** |

Table III. Percentage of males and females who engage (at any level; sometimes, often, all the time) in consumption, creation, communication behaviours, differentiated by immersion level

| | Consumption | Creation | Communication |
|---|---|---|---|
| Low Male | 43.2 | 39.8 | 27.1 |
| Low Female | 23.8 | 21.1 | 27.0 |
| High Male | 85.5 | 75.7 | 82.2 |
| High Female | 74.3 | 63.4 | 81.5 |

Table IV. Regression model for relationship between literacy reasoning and consumption behaviour

| Model 1 | b | SE b | B |
|---|---|---|---|
| Constant | 9.12 | | |
| Consumption | -2.64 | .999 | -.271** |

Note. $R^2$ =.074. p<.05*, p<.01**, p<.001***

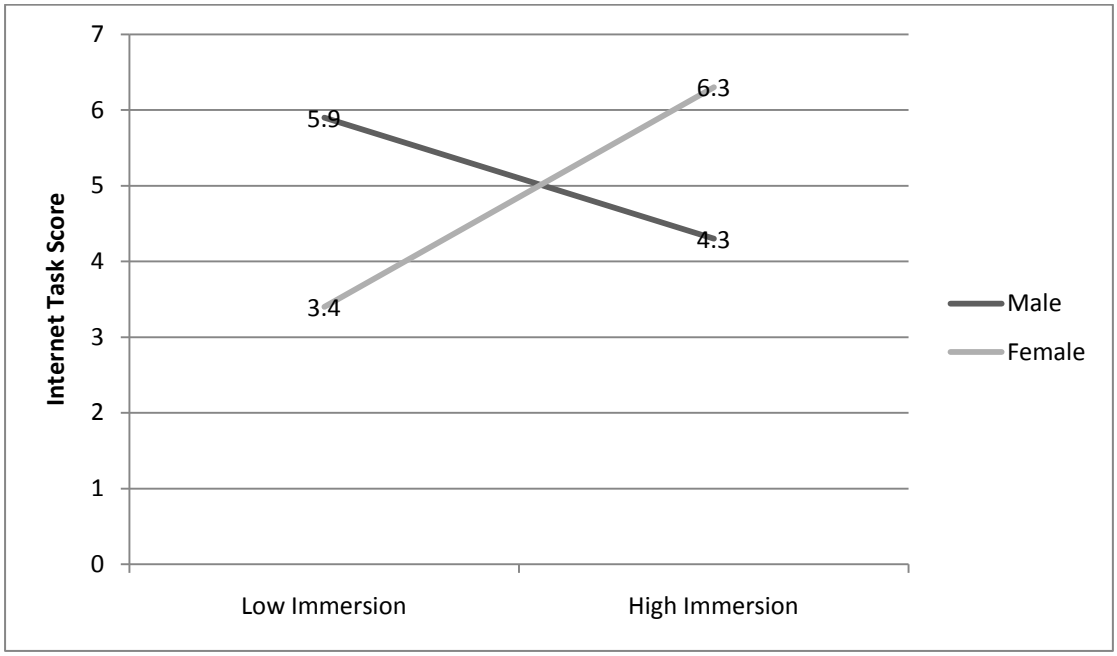


Figure 1. Internet task scores for males and females in the high and low immersion groups.

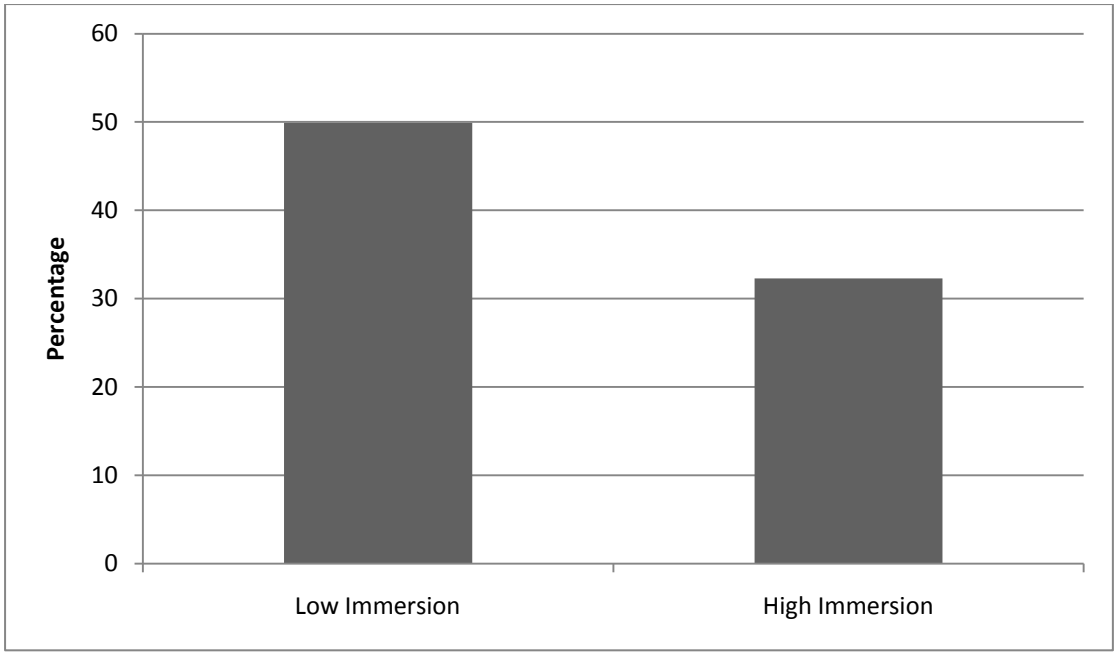

Figure 2. Percentage time spent on books by immersion group.

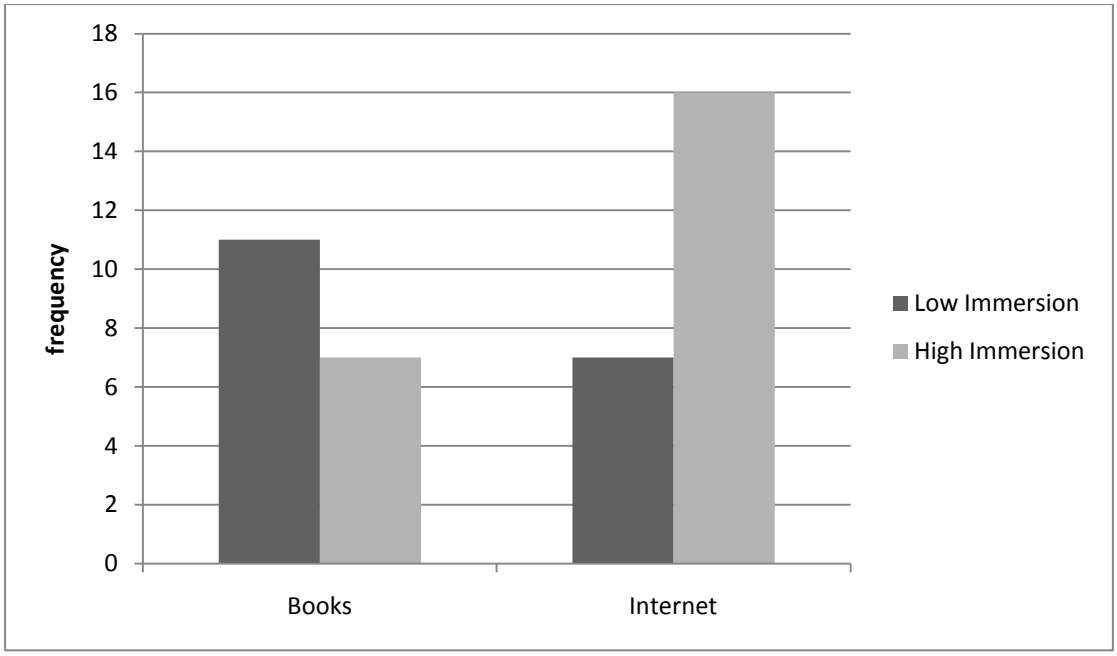


Figure 3. Number of students opting for books or internet first by immersion group.

**CONFIDENTIAL MEMO**

Can you help Professor Von Kramer?

Hello my name is Professor Von Kramer I have just built a time machine that will allow me to travel back through time. I plan to travel back in time to the year 1666. From my calculations I think I will be landing in London, England. Unfortunately, I know nothing about the year 1666 and even less about England, so I really need your help.

Can you make a report for me so that I know what to expect when I get there. I need to take lots of things with me in case I get stuck so I need to know lots about what to expect when I get there. To help you to prepare your report that will be useful for me I've listed a few important questions that I need to know the answers to:

- What isn't yet invented or discovered that I should take with me?
- Who are the important people in England in 1666?
- What important things are happening in England/London in 1666?
- What sort of clothes did they wear in 1666?
- What transport do they use in 1666?
- Any other things about where I am going to land and about the year that I'm there that might come in useful

Make sure the report is placed in my box in this room so that I can study it before I leave. You may use anything that is in this room to find the information and to prepare your report.

GOOD LUCK!

*Prof Von Kramer*

Appendix 1. Instructions given to participants for completion of the Research Task.

**HELP PLEASE**

Hi Again,

Thank you for the information you gave me to help my travel to 1666.

Now I seem to be stuck in the past and I can't get back. I really need your help. I don't have enough power in my transporter's battery to get me home. I've tried asking people here about batteries and electricity but no one seems to understand what I'm talking about. I have enough power to transport me through about 150 years but this won't get me back to my time period.

What I need you to do is to look on the internet for some information about batteries and electricity and answer the following questions for me:

- Why don't people here know about batteries and electricity?
- When were batteries invented?
- Who invented the battery?

When you get this information please send it to me by email at: VonKramer@hotmail.com
(Also, please print out a copy for my assistant)

Please help me it's awful here!

*Professor Von Kramer*

Appendix 2. Instructions given to participants for completion of the Internet Task.